Seasonality of GPA

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I. Review of Current Literature

There has thus far been limited work on the seasonality of GPA. There has been a somewhat large amount of work done on the determinants of GPA itself, but the effects of different times of the year have been left suspiciously under-researched. In the work on determinants of GPA, academics have mostly focused on GPA outputs of particular years or even entire college careers, not on the GPA output of a particular quarter or semester; in other words, most work done on GPA has focused on inter-year variation instead of intra-year seasonal variation, if individual years are considered at all.

This is not ideal. Universities wish to prepare their students in the best possible way for life post-graduation, whether that be in the job market or in graduate or professional study of some kind. This goal is certainly linked with the academic performance of their students. By understanding how academic performance fluctuates by season, it may be possible for universities to raise the GPA of students, making them more competitive in these pursuits. Although the primary pursuit of this paper is to strengthen the framework of knowledge on GPA seasonality, the results may be useful to a university in maximizing the GPA of its students; whether this is done through the rescheduling of courses or the restructuring of course curricula is beyond the scope of this paper, but it is certainly a possible topic of future work.

Much of the work that has been done on GPA has focused on collegiate athletic programs. One example of this was done by Fizel and Smaby (2004), whose paper illustrated the differences between college athletes and other students at Penn State University for a single semester in 1995, and the characteristics of each type of collegiate athlete. Their focus was mostly on GPA, but their use of a single semester and only a specific segment of the population means that their analysis cannot be used as a basis for all students, certainly not when dealing with seasonality. They did, however, show that college of enrollment was a significant factor, which could be used in this study.

Another paper, by Morgan (2005), attempted to identify predictor variables for athletes' GPA, both cognitive and noncognitive. The cognitive included typical variables such as standardized test scores, high school GPA, and cumulative college GPA. The noncognitive were more psychological factors: positive self-concept, support of one's academic plans, and involvement in the community. While these are all arguably significant, by attempting to identify predictor variables, aside from cumulative college GPA, the paper entirely ignored the variation within collegiate GPA as a result of changes during college. This would appear to be a major limitation, not allowing the predictions to be responsive to changes during college that have not already been reflected in past GPA.

These type of studies are not uncommon, as athletics are a huge source of both expenditures and income for many large schools. Unfortunately, by focusing on athletes only, factors such as seasonality are overlooked, as the researchers are focused almost entirely on the predictive power of athletes' success and never address the idea of seasonality, possibly because of the difficulty one would have trying to take into account sport seasons as well.

Another paper, by Snyder et al. (2002), focused on cognitive factors related to GPA via motivational theory. Their paper relied on "hope theory," using a 6-year longitudinal study and results from the Hope Scale to observe correlations between hopeful thinking and academic success. Their results are certainly very important and impactful, but again neglect to address changes within college aside from academic success itself; namely, seasons are again neglected as a source of GPA fluctuation. This is understandable in the context of measuring GPA at graduation, but for students that do not have an equal number of quarters or semesters for each season, seasonality may be impactful.

Self-efficacy, which is very similar to “hope,” was again found to be a good predictor for GPA in the paper by Zajacova et al. (2005). Their paper, however, mainly attempted to observe the effect that self-efficacy and stress have on minority and immigrant students, not necessarily to determine what inputs are important in the construction of GPA prediction models. They also surveyed only 107 nontraditional students at one campus of City University of New York, which is by no means a representative sample of the school.

Another take on collegiate academic outcomes was presented in a paper by Robbins et al. (2004). In their paper, they also use motivational theory to analyze other studies, but in an attempt to observe the effect of psychological and study skill factors on academic success. This, again, produces good results but neglects the intermediate GPA products in favor of final success variables.

Health is also an intuitive factor in determining academic success variables, and Trockel et al. (2010) emphasize this in their paper. Their data incorporated mostly health and psychological factors such as mood states, exercise, sleep habits, social support, stress, religious habits, and others. They found that many of these were significant, particularly religious activities and strength training, but their focus was decidedly on factors within the control of the students, not on factors that they cannot change. These, they did not investigate.

One paper that did look at GPA seasonality was published in the journal *Biological Rhythm Research* in 2011 by Şenol Beşoluk and Ismail Önder. In it, they found that GPA appeared seasonal. However, there paper was subject to some limitations. The data that they gathered was on 2479 university students in Turkey, which is a fairly small sample size. All of the students also studied education, which provides a glimpse at a particular type of student, and all of them were on semesters, which does not provide nearly the same seasonal correlation as does quarters. They also attempted to control for the starting time of classes for each student, but I think that their variable could be improved, discussed later.

II. Data

The majority of the data used in this paper has been provided by the Center for the Study of Student Life at The Ohio State University (OSU). They have received the data both from their internal data sets and from sources in other departments within the university. This includes GPA, ethnicity, gender, rank, course load, school year, place of birth, and quarter. All of the students were students at the Columbus campus of OSU, and the data set includes an observation for each quarter for every student enrolled between fall quarter 2008 and spring quarter 2011. In all, there are tens of thousands of students represented in over 305000 GPA observations, linked with their other aforementioned variables. This is helpful, as it does not give just a glimpse into student performance, but rather encapsulates the whole of the student population across time.

The variable that is focused on the most in this paper is current GPA. This is the GPA outcome of each quarter for each student that was enrolled for that particular quarter. GPA is calculated by dividing the total number of grade points attained by the total number of grade points attempted in a given quarter. At Ohio State, the grading scale is: A=4.0, A-=3.7, B+=3.3, B=3.0, B-=2.7, C+=2.3, C=2.0, C-=1.7, D+=1.3, D=1.0, and all else is equal to 0. So, grade points attained is the number of points attained for the grade (as listed above) multiplied by the number of credits for that class. Thus, in total,

$$GPA = \frac{total\ number\ of\ grade\ points\ attained}{total\ number\ of\ grade\ points\ attempted}$$

Cumulative GPA was also included in the data set; however, this is not nearly as useful to us, as current GPA is a much more preferable indication of how a student performed in any given quarter. Cumulative GPA would only show how the student has done overall, which is an extremely common focus of papers like the ones mentioned in the literature review, and would subsequently make any research into how intra-year changes affects GPA significantly more difficult.

The data is represented in the regressions by shortened variable names; data analysis packages have limits on the number of characters permitted in variable names, so it was necessary. Fall, spring, and winter are the quarters of enrollment. Summer was not included in the data set provided by the CSSL at OSU, presumably because of the significant decrease in enrollment and possibly because of the chance that a typical summer student may be different from a typical student during the other three quarters. Freshman, sophomore, junior, and senior represent the rank of each student. This does not necessarily represent age or year in school, but rather credit hours attained; at Ohio State, 0-44 credit hours is rank 1 (denoted here as frosh), 45-89 credit hours is rank 2 (denoted here as soph), and so on. White, black, asian, hispanic, pacificisle, amerindian, and undisclosed are dummy variables to denote ethnicity indicated on documents submitted by the students. These are the answers that students self-reported on how they identify their ethnicity. They denote White, Black, Asian, Hispanic, Pacific Islander, American Indian, and Undisclosed, respectively. Foreignborn represents a student that was born outside of the USA as indicated on their documents. The data on birthplace was somewhat spotty in the data set; if there was no information for birthplace, the student was not counted as foreign-born. Fulltime represents a student taking a full load of classes. At Ohio State, 12 credit hours is the lower bound (inclusive) for full time student status; this is what I used to determine the "full load." So, this denotes a student taking the necessary number of credits to be considered full time. Year0809, year0910, and year1011 are dummy variables representing the school years 2008-2009, 2009-2010, and 2010-2011, respectively. Precipdays5 and precipdays10 are variables that represent the number of days in a given quarter during which there was more than $\frac{1}{2}$ of an inch and $\frac{1}{10}$ of an inch of precipitation, respectively.

The data received from the CSSL is mostly balanced. Table 1 shows summary statistics of variables used. As one can see, fall, winter, and spring are almost equally distributed amongst the observations. There is a much larger number of "seniors" (rank 4 and above) than "freshmen," but this is to be expected; many students still attend college after attaining the minimum number of credits required to be considered rank 4. The ethnicity means are at about the levels expected for Ohio State, and the number of students considered full time also appears to be accurate (remember, this does not include students that began a particular quarter but then withdrew).

The only noticeable flaw in this data set is that it is skewed toward the more recent school years; the 2008-2009 academic year comprises only about 22.7% of the observations instead of the expected value of roughly 33%. Of course, this is partially due to the fact that more students have been enrolled each year than previous years, but this would not explain such a large disparity. However, the lack of observations from the 2008-2009 academic year does not necessarily mean that the observations from that year are somehow unusable. Table 2 shows the summary statistics of the data from the 2008-2009 academic year, and all of the variables seem to be in line with what should be expected of a proper data set. It appears viable.

Outside of the data provided by the CSSL, weather data was added to the data set. This data was requested and gathered from the National Oceanic and Atmospheric Administration (NOAA). They do not have climate information compiled for recent years from the campus of The Ohio State University (OSU); however, they do continue to collect data from the Ohio State University Airport, which is the data used in this paper. This airport is only 7 miles away from central campus, so the weather on campus can be reasonably expected to be very similar to the weather there. This data was split up by month, and the precipitation data was transferred to the data set used in this paper.

In order to create variables for precipitation data from the NOAA, the data had to be split up to correspond with the quarters, since some quarters begin or end in the middle of months. To deal with this, the expected value of the variables was calculated by contributing a proportional amount of precipitation to each quarter depending on the length of which that quarter extended into each month. For example, if a quarter extended into a month by 10 days, I attributed to that quarter roughly 1/3 of the precipitation that fell in that particular month. Seeing as the data received from the NOAA was simply days with precipitation above particular accumulation levels, this became the number of days with precipitation from that month that one could expect fell into that particular quarter. The accuracy of this is obviously not very precise, but on average across time, it should be accurate enough to be usable.

III. Analysis

The first thing done with this data was the running of an OLS regression to get a general feel for how significant all of the CSSL variables are (or are not) on current GPA [Table 3]. All of the variables are denoted as listed in the above section.

The most obvious initial observation is that the effect of fall quarter appears to be statistically significant; it looks as if fall has a statistically significant lower GPA than in spring quarter. Interestingly, here, winter quarter GPA does not appear to be statistically different than spring quarter GPA. So, this regression makes it appear that fall quarter is much worse for students than the other two quarters, during which there is no statistically significant difference in academic performance.

It also appears that the most recent academic year saw a significantly lower GPA (Graph 1). This seems odd, as the quality of entering freshman classes is supposedly steadily increasing. This effect could be due to a number of things, such as a difference in the levels of grade inflation, curves, colleges of enrollment, etc. This could be a topic of future research.

Taking a full load of courses throughout the quarter leads not just to a significant difference in current GPA, but a hugely positive one. This makes intuitive sense, as a large number of students that do not carry at least 12 credits are students that drop courses mid-quarter and subsequently receive a GPA of 0. There are also almost certainly qualitative differences between part-time and full-time students, but which must go undiscussed in this paper for lack of data.

Being born outside of the United States is also positively correlated with current GPA. This does not necessarily reflect an international student, as some internationally-born students are undoubtedly American citizens that lived in the United States before attending Ohio State; it simply reflects birthplace. At this time, "foreign born" is the best variable for which access is available, but it appears to be a very significant one.

There is, however, an obvious flaw in only running an OLS regression with this data. Most students appear more than once in this data set over time, because each student is tracked for every quarter in which they are enrolled at OSU during the period. We must attempt to control for the unobserved qualities of each student that affect current GPA, of which many cannot feasibly be included in such a data set. Thus, it is necessary to use a fixed-effects model to attempt to control for these.

In doing this, all of the variables that do not change over time for each student are omitted; so, we eliminate gender, birthplace, and ethnicity, but are able to keep the other variables that do change, such as weather, academic year, rank, and season [Table 4].

After creating this fixed-effects model, the picture becomes a bit clearer. Fall quarter is again found to be a source of lower current GPA. In addition, there is now a statistical distinction between winter and spring quarters; spring quarter appears to have a positive effect on GPA. Precipitation, specifically heavy precipitation (at least ½ of an inch in one day) is also found to make a difference in the academic success of students, although not in the way one would think; it is positively correlated with current GPA results. This is not something most people would expect, but, looking at the table, the positive effect is so tiny as to almost not make a difference at all. This effect is still particularly important, though, as it shows that the season is still important, even when controlling for bad weather. The most recent school year for which I have data (academic year 2010-2011) was also the worst in GPA terms, in line with what was found with the OLS regression in Table 3.

While it may be true that fall quarter was again significant in the fixed-effects model, one may notice that the coefficient value is much closer to 0 than in the OLS regression. Finding the reason for this is not an aim of this paper, but one potential explanation does stand out: the possibility that a student struggling too much academically in fall quarter, and hence earning a lower GPA, may not return for subsequent quarters. Of course, one cannot make this assumption without further research, which will hopefully be the case in the coming months.

It is also useful to test the results of the fixed-effects regression in Table 4 to see if fall and winter quarter GPA outcomes are statistically different from each other. Table 5 shows the result of this test; they are not. This means that, while fall and winter quarters both have worse outcomes than spring quarter when using fixed-effects, they do not necessarily have different outcomes from each other. Spring is still statistically better than either of them, but how much they differ from each other is inconclusive.

IV. Conclusion

In what may be contrary to intuition, spring quarter appears to have a somewhat positive effect on GPA compared to the other two quarters in a typical academic year. Although it is not by a huge amount (~0.020), GPA does get affected by a statistically significant amount. School administrators and research staff may want to take a closer look at what is happening.

The average GPA has also been in decline for the past two years, an event that is extra counterintuitive when the rising quality of the incoming freshman class is touted every year. Again, although it is not by much, it is enough that it should draw attention from administrators and research staff.

There are many avenues of future research that I wish to pursue with this in the future. The direction that I am most eager to pursue is the inclusion of the time of day at which each student schedules classes. As mentioned in the literature review, Beşoluk and Önder (2011) found that this was a statistically significant determinant of GPA. However, they only grouped the students into two groups, indicating whether they started classes during the first bloc of classtime (08:00-14:50) or the second bloc (15:00-21:50). This is due to the structure of the education college from which they collected data; students had to choose one bloc to attend. At Ohio State, however, students clearly have a much more open selection of times from which to choose. I wish to create an average starting time by credit hour; something like a GPA of time. For instance, if someone were to start a 3 credit hour class at 10:00 and a 5 credit hour class at 16:00, then the average starting time weighted by credit would be 13:45. I feel that this would be a much more accurate indicator than assorting the students by starting time of the first class, as GPA very much hinges on quality points obtained in high credit hour classes.

Another issue that I aim to address in the coming weeks is the fact that the most recent school year (2010-2011) has the lowest GPA; in fact, it has declined steadily for the three years for which data was supplied (Graph 1). This is interesting because the average incoming freshman class is supposedly continuously increasing in quality. One possible explanation is that transfer student quality has decreased; another is that there have been shifts in the number of students enrolled in individual colleges, which the paper by Fizel and Smaby (1999) suggests could affect GPA. These will both be explored upon receipt of appropriate data, which will be requested.

The fact that spring quarter has the best impact on GPA is also an interest not only to the author, but to the CSSL at Ohio State. Initial speculation is that students intentionally schedule easier classes than in other quarters in anticipation of a busier social life. It is also possible that spring quarter is actually not necessarily good, but that the other quarters are particularly bad. This may be the case; in autumn quarter, perhaps students are more likely to socialize because of the excitement of being back to (or arriving at) school, and in winter perhaps students are less likely to attend class due to inclement weather. Another possible explanation is that earlier in each school year, students are more likely to take sequenced classes, many of which are more "difficult" and lead to a lower GPA than non-sequenced classes. All of these possibilities are of interest to the author, and will be investigated if access to relevant data is granted.

Along those lines, this paper also presents the question of why, in the fixed-effects model, the coefficient for fall quarter is smaller in terms of absolute value than in the OLS regression. As previously stated, the possibility that struggling students may not return for subsequent quarters is one potential explanation. This question is also of interest to the CSSL at Ohio State, and will be investigated in the coming weeks.

One glaring omission in the work done in this paper is the exclusion of previous work done by students, an indication of their abilities. This was partially taken care of with the fixed-effects model included in the paper, but including standardized test scores in the initial OLS regression would almost certainly return a more attractive result. Percentiles would be used, as the two major standardized college entrance exams (ACT and SAT) have different scoring systems. This data will be requested; it will be included upon receipt.

Which students are college athletes also needs to be accounted for. Some of the papers in the literature review are about college athletes and the determinants of their GPA; Fizel and Smaby also directly state that the GPA of athletes is statistically different from the GPA of non-athletes. This must be controlled for, and preferably by sport season. For example, a female volleyball player will be listed as an athlete for the entire school year in question, but the creation of a dummy variable for "in-season" athletes would also be extraordinarily helpful. This data will be requested.

A variable for economically disadvantaged students would also be a valuable addition to this paper. This group of students may face different non-cognitive challenges that may affect their academic work, and thus would be helpful to include in these regressions. If access to this data is granted, a dummy variable will be created to identify Pell Grant recipients, which is a basic identifier of an economically disadvantaged student. This, obviously, is not a perfect indicator, but one that I think I would have the best chance of gaining access to.

One interesting facet that I wish I could have included in this paper is the psychological factors incorporated into some of the papers mentioned earlier, particularly "hope theory." Snyder et al. showed that confidence is vitally important as a determinant of academic success, and this paper has no mention of it. Unfortunately, Ohio State does not distribute such surveys to every student and does not attach the results of such surveys to student ID's or GPA records. If it could be possible to do this in the future, it would be helpful in forming a more comprehensive picture of GPA.

In the interest of accuracy, precipitation estimates will also be more accurately attached to quarters in the data set. The system used in this paper for approximating days with rainfall over a particular amount is somewhat crude; it is possible, albeit time-consuming, to actually count how many days of precipitation over a certain amount occurred during a particular quarter. The estimates will be revised upon the collection of said data.

Although this paper primarily seeks to generate new knowledge on the characteristics of GPA, its potential applicability to universities' endeavors to raise the GPA of students is also recognized. The largest possibility is probably the knowledge of seasonality of GPA being useful in rearranging course schedules to offer them at more desirable times or being used to redesigning course curricula with concerns for time of the quarter. Future work on this is possible.

Table 1

Summary Statistics of Variables 2008-2011

Variable	Obs	Mean	Std. Dev.	Min	Max
currentgpa	305208	2.920935	1.05031	0	4
fall	305208	.3394505	.4735236	0	1
winter	305208	.3311578	.4706305	0	1
female	305208	.4663672	.4988684	0	1
freshman	305208	.1828327	.3865299	0	1
sophomore	305208	.2469169	.4312187	0	1
junior	305208	.2374414	.4255156	0	1
black	305208	.0726488	.2595596	0	1
asian	305208	.0709287	.2567061	0	1
hispanic	305208	.0277286	.1641945	0	1
pacificisle	305208	.0005242	.0228902	0	1
amerindian	305208	.0050982	.0712193	0	1
undisclosed	305208	.0390717	.1937659	0	1
fulltime	305208	.8399059	.3666939	0	1
year0809	305208	.2271893	.4190166	0	1
year1011	305208	.4354145	.495812	0	1
precipdays5	305208	4.815911	2.405312	2.32	10.14
foreignborn	305208	.0684681	.2525478	0	1

Source: Data obtained from the Center for the Study of Student Life at The Ohio State Uniersity and the National Oceanic and Atmospheric Administration.

Control variables: spring, male, senior, white, 2009-2010 academic year, non-foreign

Table 2

Summary Statistics for 2008-2009 Academic Year Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
currentgpa	69340	3.052662	.8574174	0	4
fall	69340	.3348572	.4719439	0	1
winter	69340	.3303865	.4703557	0	1
female	69340	.4595472	.4983645	0	1
freshman	69340	.2478656	.4317765	0	1
sophomore	69340	.3229305	.4675998	0	1
junior	69340	.240799	.4275716	0	1
black	69340	.0712576	.2572565	0	1
asian	69340	.0604701	.2383576	0	1
hispanic	69340	.027531	.1636259	0	1
pacificisle	69340	.0004038	.020091	0	1
amerindian	69340	.0047592	.0688228	0	1
undisclosed	69340	.0381886	.1916528	0	1
precipdays5	69340	3.773454	.6776761	3	4.65
foreignborn	69340	.0606288	.2386499	0	1

Source: Data obtained from the Center for the Study of Student Life at The Ohio State University and the National Oceanic and Atmospheric Administration.

Control variables: spring, male, senior, white, 2009-2010 academic year, non-foreign.

Table 3

OLS Regression 2008-2011

Source	SS	df	MS
Model	69986.8984	17	4116.87637
Residual	266702.364	305190	.87388959
Total	336689.262	305207	1.10315053

Number of obs	= 305208
F(17,305190)	= 4710.98
Prob > F	= 0.0000
R-squared	= 0.2079
Adj R-squared	= 0.2078
Root MSE	= .93482

currentgpa	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
fall	-.0367525	.0045125	-8.14	0.000	-.0455969	-.0279081
winter	.0084828	.0058521	1.45	0.147	-.0029872	.0199528
female	.1753141	.0034002	51.56	0.000	.1686497	.1819784
freshman	-.009868	.0050717	-1.95	0.052	-.0198083	.0000724
sophomore	-.1057773	.004623	-22.88	0.000	-.1148382	-.0967163
junior	-.0879448	.0046156	-19.05	0.000	-.0969911	-.0788984
black	-.3666983	.0066153	-55.43	0.000	-.379664	-.3537325
asian	-.0145751	.0072367	-2.01	0.044	-.0287588	-.0003913
hispanic	-.1166114	.0103561	-11.26	0.000	-.1369091	-.0963136
pacificisle	.0217309	.073936	0.29	0.769	-.1231816	.1666435
amerindian	-.1765345	.0237785	-7.42	0.000	-.2231396	-.1299293
undisclosed	-.1173709	.0102411	-11.46	0.000	-.1374431	-.0972986
fulltime	1.222178	.0046954	260.29	0.000	1.212976	1.231381
year0809	.093907	.0046558	20.17	0.000	.0847819	.1030322
year1011	-.0698148	.0042085	-16.59	0.000	-.0780633	-.0615663
precipdays5	.0041341	.0010559	3.92	0.000	.0020646	.0062036
foreignborn	.1641322	.0082736	19.84	0.000	.1479163	.1803482
_cons	1.885428	.0087805	214.73	0.000	1.868218	1.902638

Source: Data obtained from the Center for the Study of Student Life at The Ohio State University and the National Oceanic and Atmospheric Administration.

Control variables: spring, male, senior, white, 2009-2010 academic year, non-foreign.

Table 4

Fixed-Effects Regression 2008-2011

```
Fixed-effects (within) regression               Number of obs      =    305208
Group variable: emplid                          Number of groups   =     53579

R-sq:  within  = 0.0938                         Obs per group: min =         1
       between = 0.3504                                        avg =       5.7
       overall = 0.1886                                        max =         9

                                                F(6,251623)        =   4339.41
corr(u_i, Xb)  = 0.1996                         Prob > F           =    0.0000
```

currentgpa	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
fall	-.020542	.005957	-3.45	0.001	-.0322176	-.0088664
winter	-.0193595	.0071288	-2.72	0.007	-.0333317	-.0053872
fulltime	.8458062	.0056121	150.71	0.000	.8348066	.8568058
precipdays10	-.0019789	.0005255	-3.77	0.000	-.0030088	-.0009489
year0809	.072228	.0040262	17.94	0.000	.0643367	.0801193
year1011	-.0823248	.0036221	-22.73	0.000	-.089424	-.0752255
_cons	2.271836	.0124078	183.10	0.000	2.247517	2.296155
sigma_u	.79107751					
sigma_e	.74279669					
rho	.53144523	(fraction of variance due to u_i)				

F test that all u_i=0:   F(53578, 251623) =   4.52   Prob > F = 0.0000

Source: Data obtained from the Center for the Study of Student Life at The Ohio State University and the National Oceanic and Atmospheric Administration.

Table 5

Test of Fall=Winter for Fixed-Effects Regression 2008-2011 [Table 4]

```
 ( 1)  fall - winter = 0

       F(  1,251623) =    0.11
            Prob > F =    0.7421
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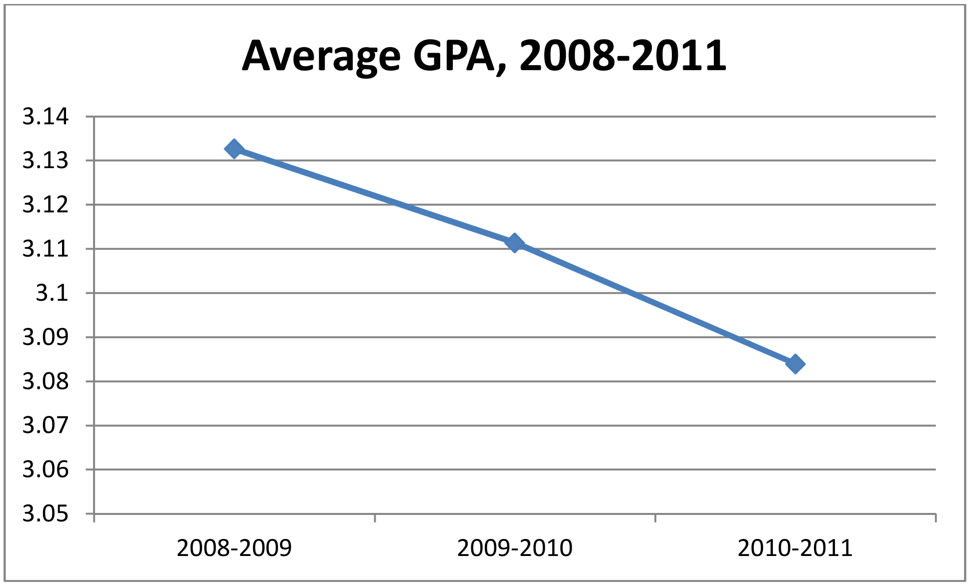
Source: Data obtained from the Center for the Study of Student Life at The Ohio State University.

Graph 1



Source: Data obtained from the Center for the Study of Student Life at The Ohio State University.

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